US011543619B2

(12) **United States Patent**
Sekiguchi

(10) **Patent No.: US 11,543,619 B2**
(45) **Date of Patent: Jan. 3, 2023**

(54) **LENS DRIVING DEVICE, CAMERA DEVICE AND ELECTRONIC APPARATUS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 99 days.

(21) Appl. No.: **16/776,715**

(22) Filed: **Jan. 30, 2020**

(65) **Prior Publication Data**

US 2020/0183122 A1 Jun. 11, 2020

Related U.S. Application Data

(63) Continuation-in-part of application No. 16/205,463, filed on Nov. 30, 2018, now Pat. No. 10,591,705, which is a continuation-in-part of application No. 15/429,283, filed on Feb. 10, 2017, now Pat. No. 10,175,450.

(30) **Foreign Application Priority Data**

Feb. 17, 2016 (JP) 2016-027741

(51) **Int. Cl.**
G02B 7/02 (2021.01)
G02B 7/04 (2021.01)

(52) **U.S. Cl.**
CPC ***G02B 7/04*** (2013.01)

(58) **Field of Classification Search**
CPC G02B 7/04
See application file for complete search history.

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(74) *Attorney, Agent, or Firm* — Fildes & Outland, P.C.

(57) **ABSTRACT**

A lens driving device includes: a box-shaped lens carrier for fixing a lens barrel to the inside thereof which lens barrel is for guiding light from an imaging target to a photo detecting sensor, wherein the lens carrier has a first opening through which light from the imaging target enters, a second opening through which light toward the photo detecting sensor exits, and a third opening for mounting the lens barrel, wherein the third opening is formed between ends of two opposing side walls of the box-shaped lens carrier other than side walls being formed with the first opening and the second opening, wherein inner surfaces of the two opposing side walls are formed in parallel with respect to each other from the third opening to the center of the lens carrier.

11 Claims, 8 Drawing Sheets

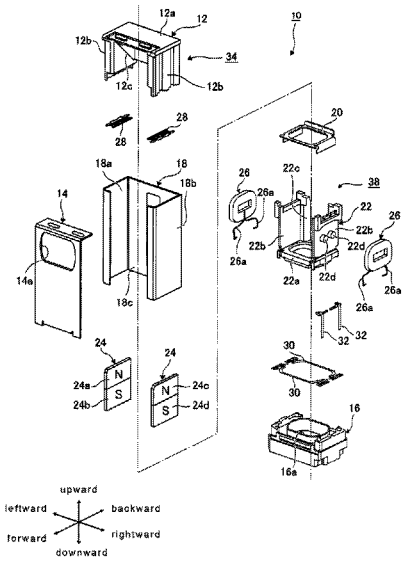

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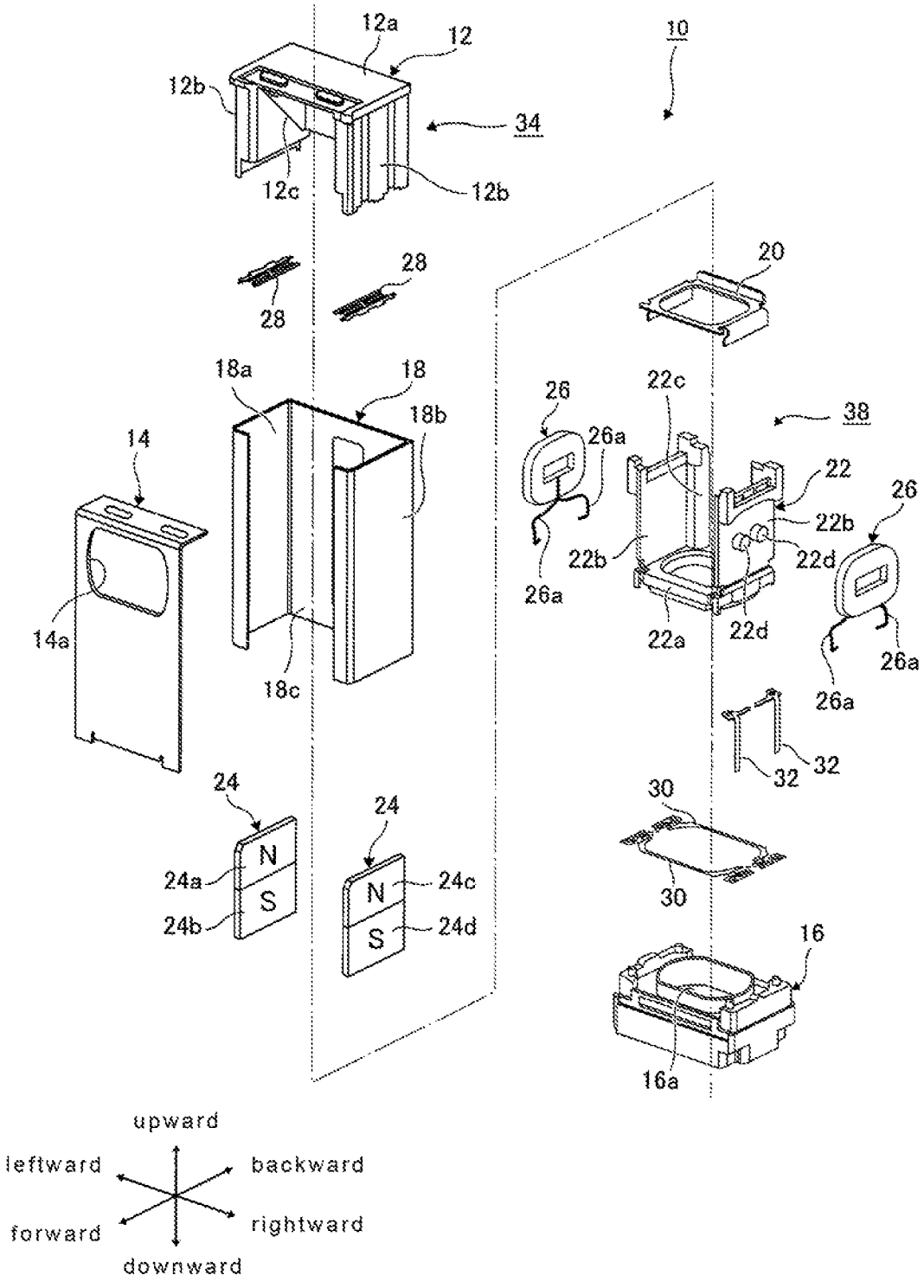
FIG. 1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12
10
12b
34
12c
12b
28
28
20
18a
18
18b
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22c
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26a
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26
22b
22b
22d
14a
26a
22a
22d
26a
18c
26a
32
32
24
30
24
N
24a
S
24b
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S
24d
30
16
16a
upward
leftward
backward
forward
rightward
downward

FIG. 2

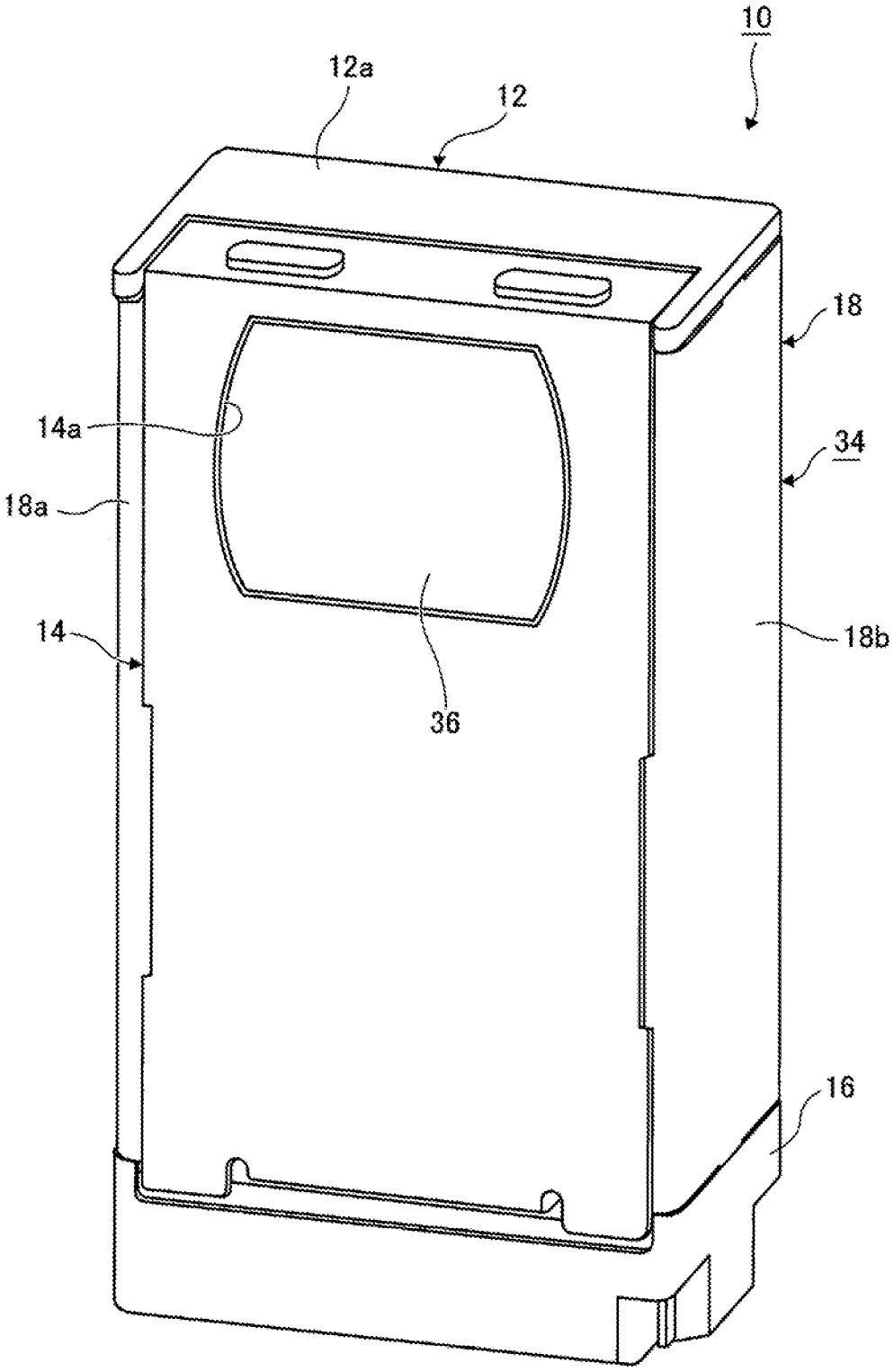


FIG. 3

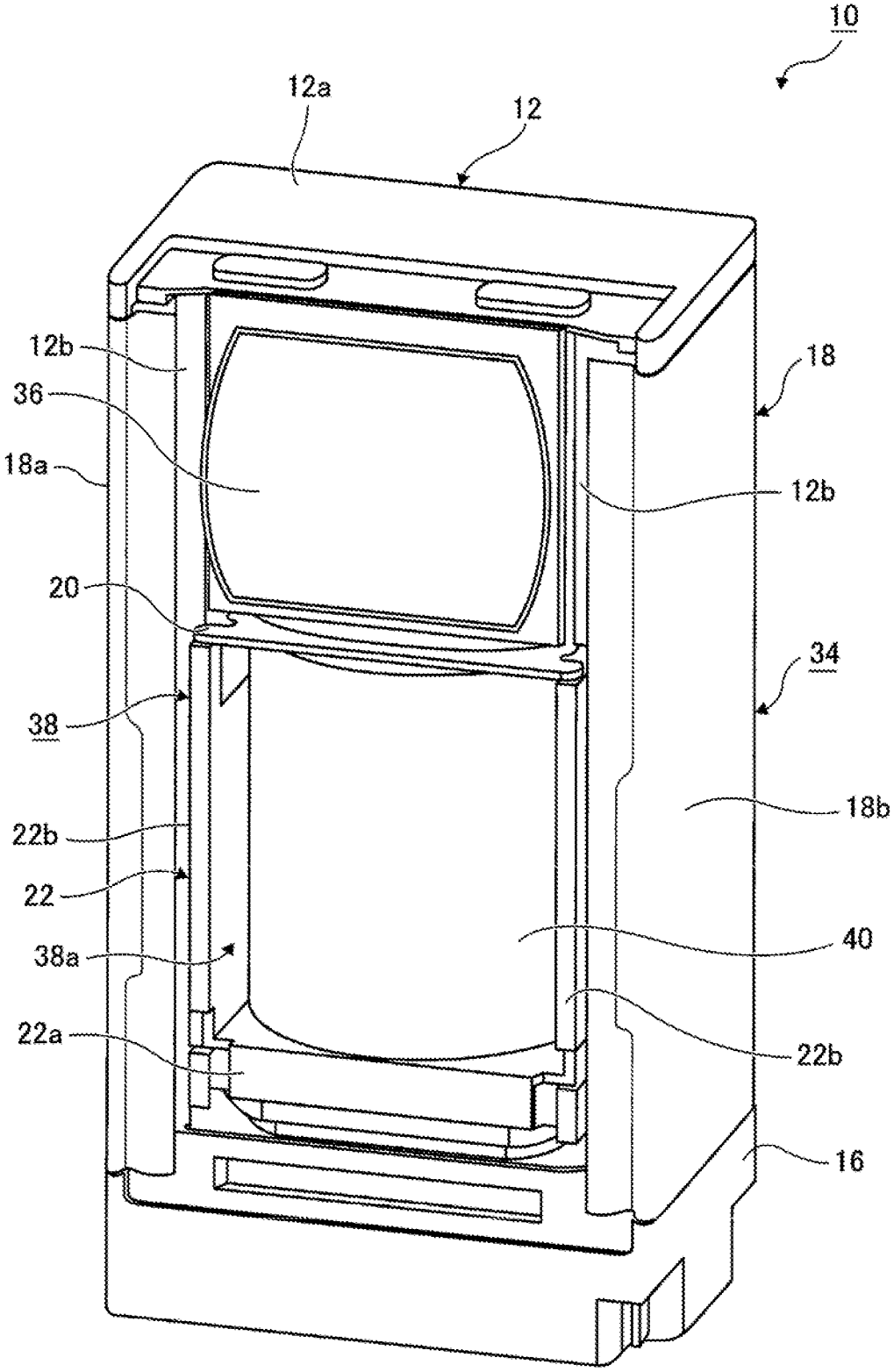
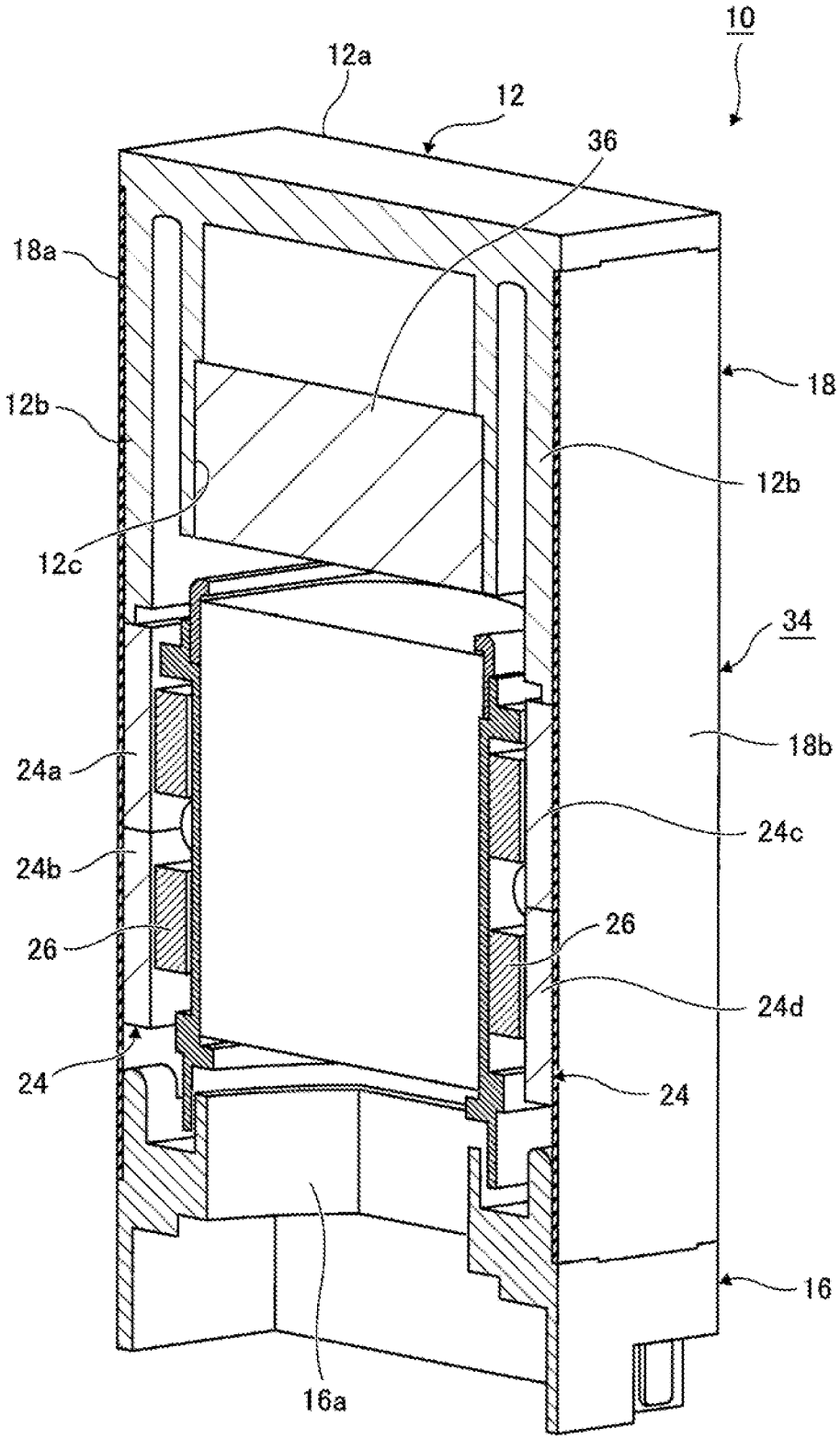


FIG. 4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12a
12
36
18a
18
12b
12b
12c
34
18b
24a
24c
24b
26
26
24d
24
24
16
16a

FIG. 5

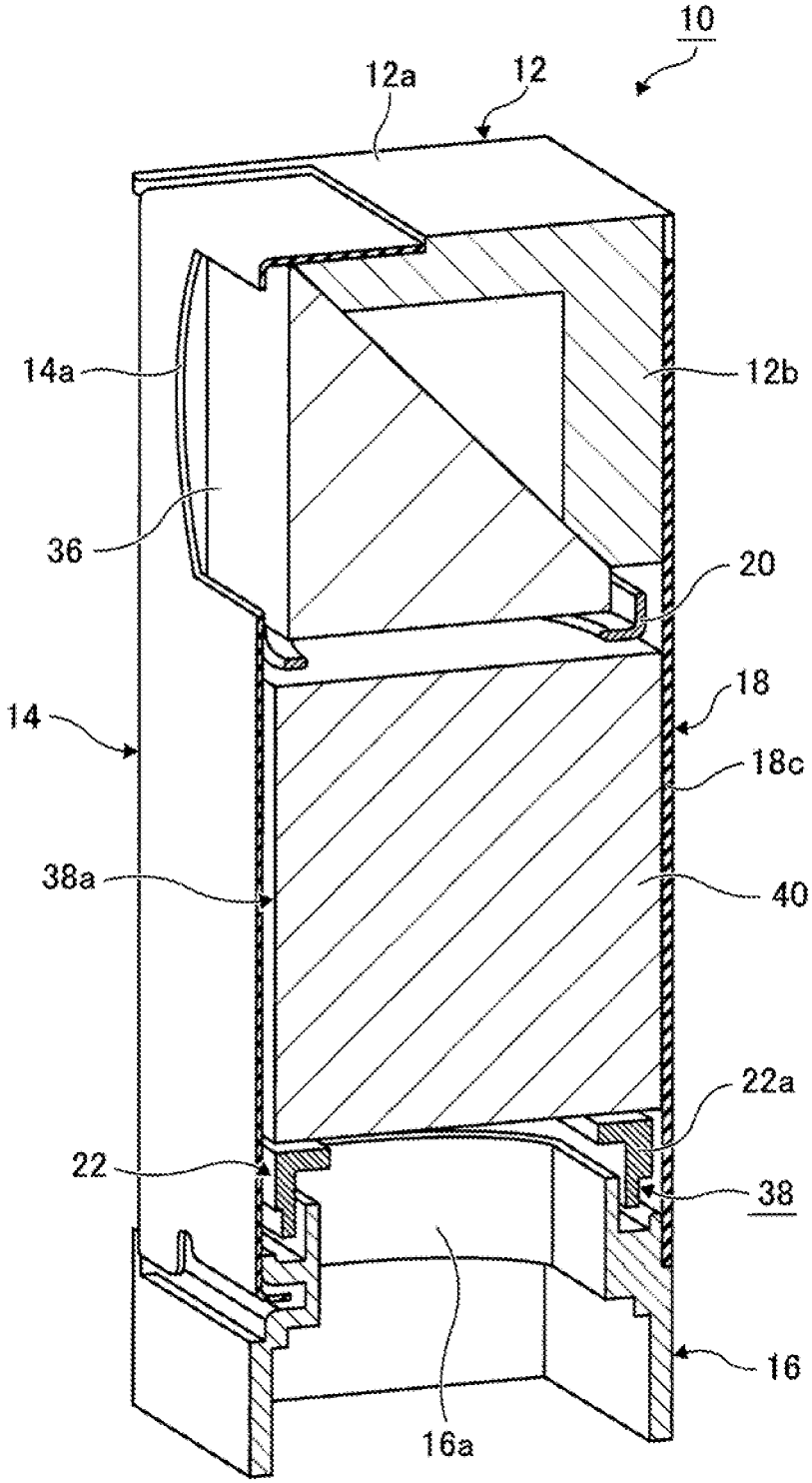


FIG. 6

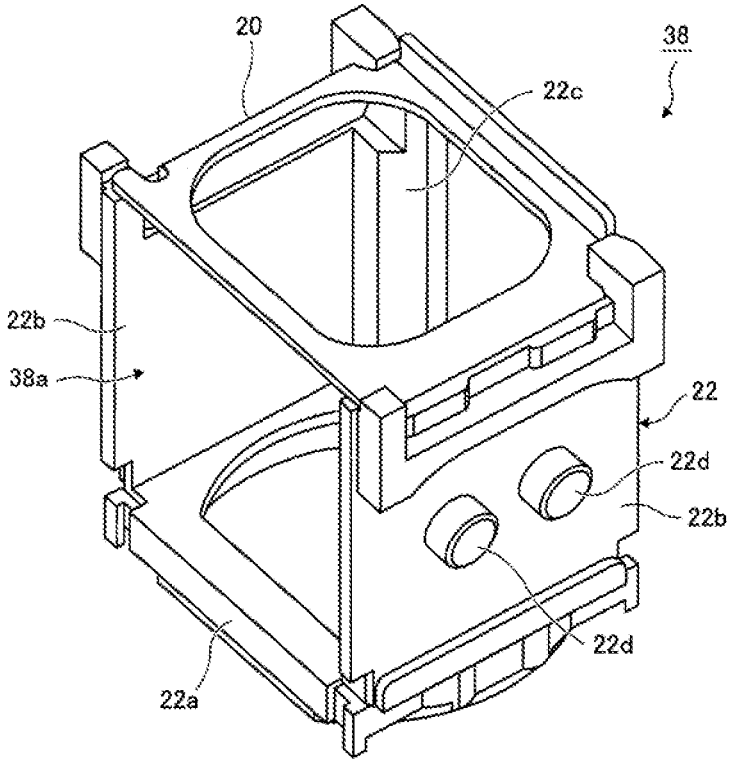


FIG. 7

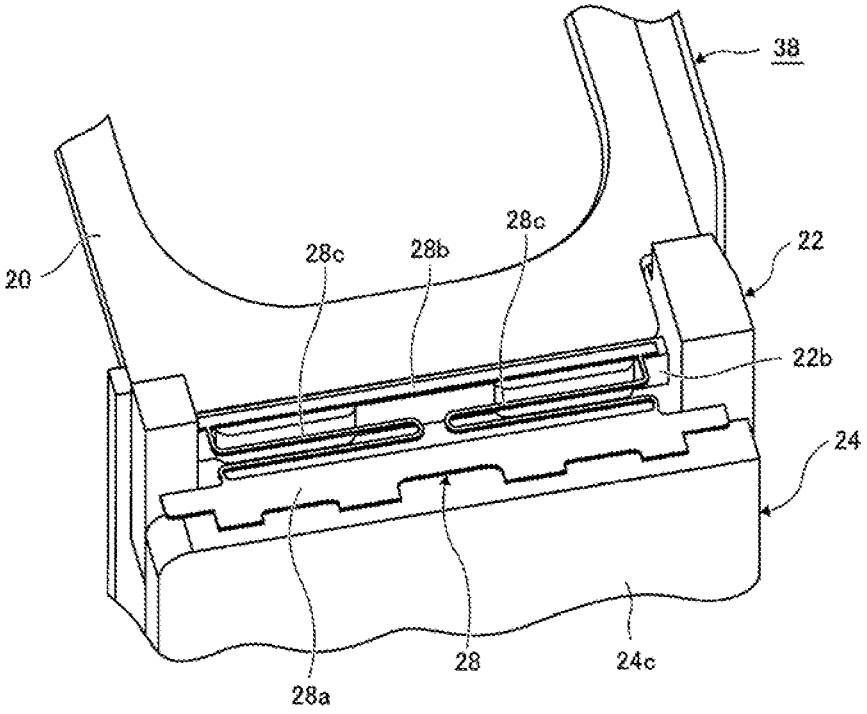
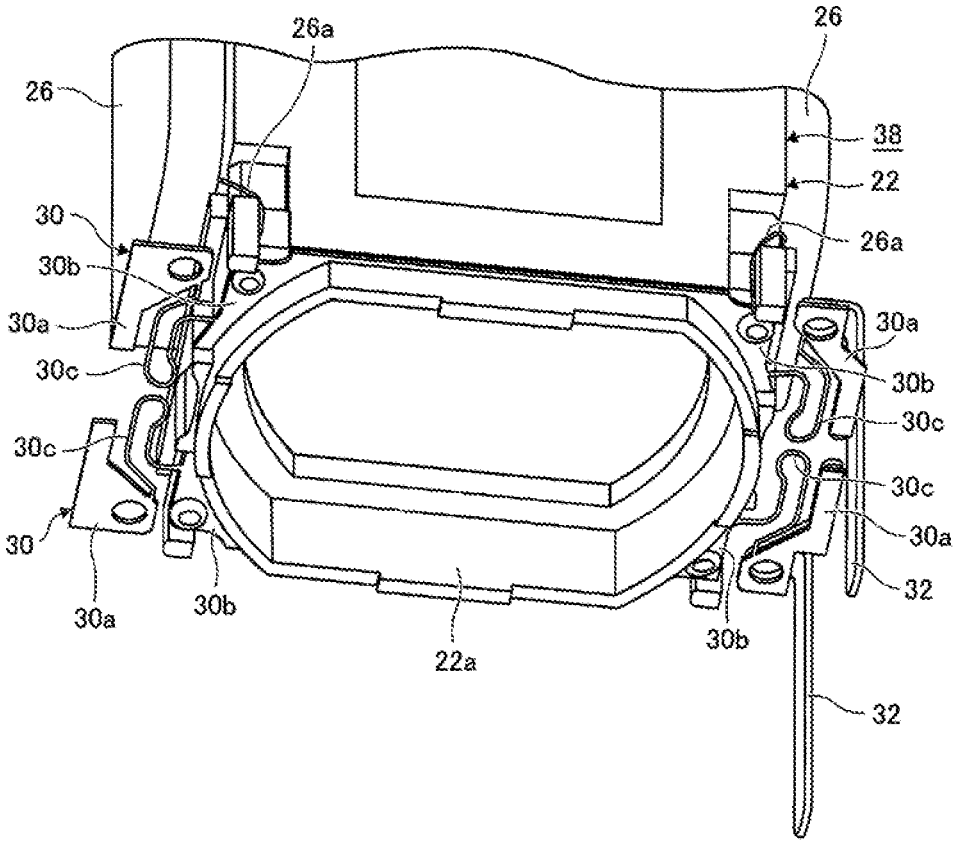


FIG. 8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30
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30a
30b
22a
30b
32

LENS DRIVING DEVICE, CAMERA DEVICE AND ELECTRONIC APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

This application is continuation-in-part of U.S. patent application Ser. No. 16/205,463 filed on Nov. 30, 2018 entitled "LENS DRIVING DEVICE, CAMERA DEVICE AND ELECTRONIC APPARATUS", which was continuation-in-part of U.S. patent application Ser. No. 15/429,283 filed on Feb. 10, 2017 of the same title, and the entire contents of the above U.S. Patent applications are incorporated herein by reference.

TECHNICAL FIELD

This invention relates to a lens driving device, a camera device and an electronic apparatus.

BACKGROUND ART

Electronic apparatuses such as cellular phones and smart phones are equipped with miniaturized cameras. The miniaturized camera of this type is an automatic focusing type. The miniaturized camera of this automatic focusing type includes a lens driving device for actuating the lens barrel to move.

The Japanese Unexamined Patent Application Publication No. 2010-134409A discloses a lens driving device in which a lens barrel is fixed inside a lens carrier and the lens carrier is moved along the optical axis direction of the lens barrel thereby adjusting the focus.

SUMMARY

In the above prior art, a main body is formed with an opening portion which opens toward the optical axis direction of the lens barrel through which opening portion the lens barrel is inserted along the optical axis direction and thereafter the lens barrel is fixed to the lens carrier. The lens barrel is slid and fit into the lens carrier without an aid of threads at the portion between the lens barrel and the lens carrier. Therefore, the above Japanese Unexamined Patent Application Publication No. 2010-134409A explains that the lens driving device can be miniaturized since both the lens barrel and the lens carrier do not need to have any threads.

However, since the lens barrel has to be inserted into the lens carrier in a sliding manner from the optical axis direction, there needs to have a sliding wall for the lens barrel to be slid inside the lens carrier. Therefore, the lens carrier cannot be miniaturized, and it hinders the miniaturization of the lens driving device.

The present invention aims to solve the problem of the prior art, and to provide a lens driving device, camera device and an electronic apparatus which are able to be miniaturized.

In one aspect of the present invention, a lens driving device is provided. The lens driving device includes: a box-shaped lens carrier for fixing a lens barrel to the inside thereof which lens barrel is for guiding light from an imaging target to a photo detecting sensor, wherein the lens carrier has a first opening through which light from the imaging target enters, a second opening through which light toward the photo detecting sensor exits, and a third opening for mounting the lens barrel, wherein the third opening is formed between ends of two opposing side walls of the box-shaped lens carrier other than side walls being formed with the first opening and the second opening, wherein inner surfaces of the two opposing side walls are formed in parallel with respect to each other from the third opening to the center of the lens carrier.

Preferably, the lens carrier has a fourth opening between ends of the two opposing side walls at the side opposite to the third opening.

Preferably, a distance between the two opposing side walls at the fourth opening is smaller than a distance between the two side walls at the third opening.

Preferably, the lens driving device further includes an optical component being provided between the imaging target and the first opening for receiving light from a front and guiding toward the first opening, wherein the third opening is formed at a front side of the lens carrier.

Preferably, the lens driving device further includes a lens driving device housing supporting the lens carrier, wherein the third opening enables the lens barrels to be mounted thereto in a state the lens carrier is supported by the lens driving device housing.

Preferably, the lens driving housing encloses the lens carrier, wherein the third opening directly faces the lens driving housing.

Preferably, the lens driving device further has a cover closing a front side thereof, wherein the cover directly faces the third opening.

Preferably, the lens carrier is driven along an optical axis direction of the lens barrel.

In another aspect of the present invention, a camera device includes: a lens barrel; a lens driving device of the above aspects; and a photo detecting sensor that receives light passed through the lens barrel.

In another aspect of the present invention, an electronic apparatus being equipped with a camera device includes: a lens barrel; a lens driving device of the above aspects; and a photo detecting sensor that receives light passed through the lens barrel.

According to the present invention, since the lens carrier has the opening through which the lens barrel can be inserted from the direction intersecting the optical axis of the lens barrel, the lens carrier can be miniaturized, thus the lens driving device, the camera device and the electronic apparatus can also be miniaturized.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows an exploded perspective view of a lens driving device according to an embodiment of the present invention.

FIG. **2** shows a perspective view of the lens driving device according the embodiment of the present invention.

FIG. **3** shows the lens driving device according to the embodiment of the present invention and shows a perspective view of the lens driving device of FIG. **2** in a state a cover member is removed.

FIG. **4** shows the lens driving device according to the embodiment of the present invention and shows a sectional perspective view cut by a plane which includes the optical axis of the lens barrel and expands in the vertical direction and a right-and-left direction.

FIG. **5** shows the lens driving device according to the embodiment of the present invention and shows a sectional perspective view cut by a plane which includes the optical axis of the lens barrel and expands in the vertical direction and a front-and-back direction.

FIG. **6** shows the lens carrier used for the lens driving device according to the embodiment of the present invention.

FIG. **7** shows a perspective view of upper leaf springs in the lens driving device according to the embodiment of the present invention.

FIG. **8** shows a perspective view of the lower leaf springs in the lens driving device viewing from the lower side according to the embodiment of the present invention.

EXEMPLARY EMBODIMENT OF THE INVENTION

An embodiment of the present invention will be described hereinafter with reference to the drawings.

FIG. **1** shows an exploded perspective view of a lens driving device according to an embodiment of the present invention. The lens driving device **10** includes an upper member **12**, a cover member **14**, a lower member **16**, a yoke **18**, a reinforcement member **20**, a main body **22** of the lens carrier, magnets **24**, coils **26**, upper leaf springs **28**, lower leaf springs **30** and terminals **32**. A main body **22** of the lens carrier is supported by the upper leaf springs **28** and the lower leaf springs **30** which form an elastic supporter for the lens carrier so that the main body **22** of the lens carrier can move freely along the optical axis direction of the lens barrel **40**.

In the following description, as shown in FIG. **1**, one direction along the optical axis direction of the lens barrel **40** described later is referred to as "upward" direction while the opposing direction thereto is referred to as "downward" direction. The one direction orthogonal to the optical axis direction of the lens barrel **40** is referred to as "forward" direction while the opposing direction thereto is referred to as "backward" direction. Further, the one direction orthogonal to the upward-and-downward direction and the forward-and-backward direction is referred to as "leftward" direction while the opposing direction thereto is referred to as "rightward" direction.

The upper member **12** has a top wall **12***a* and side walls **12***b* extending downwardly from the right and left ends and the back end of the top wall **12***a*. The lateral side walls **12***b* are formed inside thereof with inclined parts **12***c* for positioning a prism **36** which is described later.

The cover member **14** is formed with a light entrance window **14***a* through which the light enters. The lower member **16** is formed as a rectangular parallelepiped shape and is formed at inside thereof with a light exit window **16***a* through which the light exits. The lower member **16** is installed with an IR filter and an optical sensor when the camera device mentioned below is assembled.

The yoke **18** is formed as a U-shaped member including three walls, i.e. a left side wall **18***a*, a right side wall **18***b* and a back side wall **18***c* which surround an internal space except the front portion. As for the front portion, the distal ends of the left side wall **18***a* and the right side wall **18***b* are bent in a manner to be directed toward each other.

A lens driving device housing **34** is composed of the upper member **12**, the cover member **14**, the lower member **16** and the yoke **18**. That is, the lens driving device housing **34** is assembled by the following manner: fitting the upper member **12** into the yoke **18** so that the outer faces of the side walls **12***b* of the upper member **12** are fit inside the internal faces of the left side wall **18***a*, right side wall **18***b* and back side wall **18***c*; fitting the lower member **16** into the yoke **18** so that the outer faces of the lower member **16** are fit inside the internal faces of the left side wall **18***a*, right side wall **18***b* and back side wall **18***c*; and fitting the cover member **14** into the upper member **12**, the lower member **16** and the yoke **18**. Thus the lens driving device housing **34** forms a parallelepiped shape having a hollow space inside thereof so as to block up the front face of the yoke **18**.

As shown in FIGS. **2** to **5**, the prism **36** is fixed inside the upper member **12**. The prism **36** is an optical component which forms an optical system bending the optical axis direction and has a triangle cross section. The prism **36** is arranged so that the front face thereof is fit behind the light entrance window **14***a* of the cover member **14**, the both lateral sides of an inclined back surface thereof, or a reflect surface, abut along the inclined parts **12***c* of the upper member **12** and the lower face directs downward. Thus, the prism **36** receives the light from the front face and thereafter reflects the light at the inclined back surface toward the downward direction.

As best shown in FIG. **6**, the reinforcement member **20** and the main body **22** of the lens carrier are assembled together to form the lens carrier **38**. The main body **22** of the lens carrier is formed of resin and has a bottom portion **22***a* having a rectangular frame shape and coil mounting portions **22***b* extending upwardly from the lateral ends of the bottom portion **22***a*. The reinforcement member **20** is formed of a metal such as stainless steel and is formed as a rectangular frame shape. The reinforcement member **20** reinforces the main body **22** of the lens carrier by means of the lateral sides thereof being fixed to the upper ends of the coil mounting portions **22***b* of the main body **22** of the lens carrier from the inside thereof.

The lens carrier **38**, as shown in FIGS. **3** and **5**, has an opening **38***a* through which the lens barrel **40** can be inserted. The opening **38***a* is formed so as to be surrounded by the reinforcement member **20**, the bottom portion **22***a* of the main body **22** of the lens carrier and the coil mounting portions **22***b*. The opening **38***a* opens toward the front direction. During the assembly process, as shown in FIG. **3**, the lens barrel **40** is inserted through the opening **38***a* from the front side into the lens carrier **38** previous to the assembly of the cover member **14**.

The main body **22** of the lens carrier is formed with abutment surfaces **22***c* for the lens barrel at the internal surfaces of the back ends of the coil mounting portions **22***b* thereof. The lens barrel **40** includes a lens, has a cylindrical shape, abuts to the internal surfaces of the coil mounting portions **22***b* and to the abutment surfaces **22***c* for the lens barrel, and is fixed to the lens carrier **38** by making use of an adhesive material.

As best shown in FIG. **4**, the magnets **24** includes four rectangular magnetic pieces **24***a*, **24***b*, **24***c* and **24***d*. Two magnetic pieces **24***a* and **24***b* are arranged adjoining along the upward-and-downward direction each other and are fixed to the internal surface of the left side wall **18***a* of the yoke **18**. The other two magnetic pieces **24***c* and **24***d* are also arranged adjoining along the upward-and-downward direction each other and are fixed to the internal surface of the right side wall **18***b* of the yoke **18** in a manner to be aligned with the magnetic pieces **24***a* and **24***b* with respect to the upward-and-downward direction. Each of the magnetic pieces **24***a*, **24***b*, **24***c* and **24***d* is magnetized so that the outer surface and the inner surface thereof have the different magnetic polarities. Further, each adjoining inner surface and each opposing inner surface of the magnetic pieces **24***a*, **24***b*, **24***c* and **24***d* exhibits different magnetic pole each other. For example, if the inner surface of the magnetic piece **24***a* is the N-pole, the inner surfaces of the magnetic pieces **24***b* and **24***c* are the S-pole while the inner surface of the

magnetic piece **24***d* is the N-pole. It is possible that the magnetic pieces **24***a* and **24***b*, as well as the magnetic pieces **24***c* and **24***d*, can be integrally formed, respectively. In that case, the magnetic pieces can be magnetized so that the inner surface of the magnetic piece **24***a* (**24***c*) and the inner surface of the magnetic piece **24***b* (**24***d*) exhibit different magnetic polarities.

As shown in FIG. **6**, the each coil mounting portion **22***b* of the main body **22** of the lens carrier is formed with two positioning projections **22***d* projecting outwardly in a manner that they are aligned each other in the forward-and-backward direction.

The each coil **26** is formed to have a shape including two linear parts and semicircular parts connected to the both ends of the each linear part. The coil **26** has an air core for positioning around the positioning projections **22***d* and is positioned thereto by fitting around the positioning projections **22***d* thereby being fixed to the lens carrier **38** by making use of an adhesive material. The linear parts of the coils **26** are confronted to the magnetic pieces **24***a* to **24***d* of the magnets **24**. Since electric current flows through the linear parts of the each coil **26** in the forward-and-backward direction and magnetic flux is produced toward the leftward-and-rightward direction of the each coil **26**; therefore, an electromagnetic force toward the upward-and-downward direction is applied to the lens carrier **38**.

A pair of upper leaf springs **28** is provided at both right and left sides. As shown in FIG. **7**, each of the upper leaf spring **28** includes a main body side fixing portion **28***a*, a lens carrier side fixing portion **28***b* and two spring portions **28***c*. The main body side fixing portion **28***a* is fixed onto the upper end of the magnet **24**. The lens carrier side fixing portion **28***b* is fixed onto the upper end of the coil mounting portion **22***b* of the main body **22** of the lens carrier. The spring portion **28***c* is formed as a wire shape with two bent portions and connects the main body side fixing portion **28***a* with the lens carrier side fixing portion **28***b* so as to exert an elastic force. The upper leaf springs **28**, as a whole structure, include four spring portions **28***c*, thus the lens carrier **38** is supported at four perimeter places thereof. The upper leaf springs **28** are attached to the both lateral sides of the lens carrier **38** in a manner that surface of each upper leaf spring **28** is oriented orthogonal to the optical axis direction and they support the lens carrier **38** in a manner to freely move in the optical axis direction of the lens barrel **40** with respect to the lens driving device housing **34**.

The lower leaf springs **30**, as a whole structure, are divided into two parts in the forward-and-backward direction, and each lower leaf spring **30** has two spring members at the lateral ends thereof. The each lower leaf spring **30**, as shown in FIG. **8**, has two main body side fixing portions **30***a*, a lens carrier side fixing portion **30***b* and two spring portions **30***c*. The each main body side fixing portion **30***a* is fixed on to the upper end of the lower member **16**. The lens carrier side fixing portion **30***b* is fixed on the bottom portion **22***a* of the main body **22** of the lens carrier. The each spring portion **30***c* is formed as a wire shape with two bent portions and connects the main body side fixing portion **30***a* with the lens carrier side fixing portion **30***b* so as to exert an elastic force. The lower leaf springs **30**, as a whole structure, include four spring portions **30***c*, thus the lens carrier **38** is supported at four perimeter places thereof. The lower leaf springs **30** are attached to the both front and back sides and the both lateral sides of the lens carrier **38** in a manner that surface of each lower leaf spring **30** is oriented orthogonal to the optical axis direction and they support the lens carrier **38** in a manner to freely move in the optical axis direction of the lens barrel **40** with respect to the lens driving device housing **34**.

Further, the lower leaf springs **30** are used as electro conductive members. As shown in FIG. **8**, the ends **26***a* of the above-mentioned coils **26** are connected to the lens carrier side fixing portions **30***b* of the lower leaf springs **30** which are divided each other.

Two terminals **32** are connected to the main body side fixing portions **30***a* of the lower leaf springs **30** and are also fixed to the lower member **16** together with the main body side fixing portions **30***a*. These terminals **32** extend apart from the center of the lens barrel **40** toward the right direction, for example, and extend downward along the side surface of the lower member. An electric current input to one of the terminals **32** flows through the two coils **26** via one of the lower leaf springs **30** and output from the other one of the terminals **32** via the other one of the lower leaf springs **30**. The coils **26** are electrically connected in parallel to the terminals **32**.

A photo detecting sensor for receiving light which is passed through the lens barrel **40** via an IR filter is arranged below the lower member **16** so as to form a camera device.

In the camera device, the light incident to the prism **36** from an imaging target turns at right angle due to the effect of the prism **36** and is concentrated by the lens barrel **40** onto the photo detecting sensor so as to be detected thereby. A controller which is provided in the camera calculates a movement amount of the lens barrel **40** for focusing on the imaging target. The controller controls an electric voltage to be applied to the terminals **32** in a manner the voltage corresponds to the movement amount of the lens. When electric current flows through the coils **26** via the terminals **32** and the lower leaf springs **30**, a magnetic flux from the magnets **24** acts on the coils **26**, and an upward and downward moving force is generated in the coils **26**. When the electromagnetic force is generated in the coils **26**, the lens carrier **38** together with the lens barrel **40** moves against the counterforce of the upper leaf springs **28** and the lower leaf springs **30**, thus the lens is focused on the imaging target.

As shown in the above embodiment, since there are not any obstacles obstructing the lens barrel **40** to be inserted into the lens carrier **38** in the front side thereof, it is easy to insert the lens barrel **40** into the lens carrier **38**. However, the present invention is not limited to the above example. It can also be possible to form the opening **38***a* of the lens carrier **38** in a manner that the lens barrel **40** can be inserted from one of the lateral sides of the lens carrier **38** or the back side of the lens carrier **38**. Further, the present invention is not limited to the examples in which the lens barrel **40** is inserted into the lens carrier **38** along the direction orthogonal to the optical axis direction of the lens barrel **40**. It can also be possible to insert the lens barrel **40** thereto along any direction which intersects the optical axis direction of the lens barrel **40** at any angle; e.g. the lens barrel **40** can be inserted into the lens carrier **38** from a diagonal direction with respect to the optical axis direction. Further, in the above embodiment, the prism **36**; i.e. the optical component forming an optical system which folds the optical axis is arranged on the optical axis direction. However, the present invention can be applied to other embodiments which do not include any optical component such as the one described above.

What is claimed is:

1. A lens driving device comprising:

a box-shaped lens carrier for fixing a lens barrel to the inside thereof which lens barrel is for guiding light from an imaging target to a photo detecting sensor, wherein

the lens carrier has two parallelly opposing side walls each of which has an upper end, a lower end, a front end, and a rear end, wherein

a first opening through which light from the imaging target enters is formed between the upper ends of the two parallelly opposing side walls, a second opening through which light toward the photo detecting sensor exits is formed between the lower ends of the two parallelly opposing side walls, a third opening for mounting the lens barrel is formed between the front ends of two parallelly opposing side walls, and a fourth opening is formed between the rear ends of two parallelly opposing side walls, wherein

inner surfaces of the two parallelly opposing side walls are formed in parallel with respect to each other from the front ends to the center of the lens carrier.

2. The lens driving device according to claim 1, wherein a distance between the two parallelly opposing side walls at the fourth opening is smaller than a distance between the two parallelly opposing side walls at the third opening.

3. The lens driving device according to claim 1, further including an optical component being provided between the imaging target and the first opening for receiving light from a front side of the lens driving device and guiding toward the first opening, wherein the third opening of the lens carrier is formed at the front side of the lens driving device.

4. The lens driving device according to claim 1 further including a lens driving device housing supporting the lens carrier, wherein the third opening enables the lens barrel to be mounted thereto in a state that the lens carrier is supported by the lens driving device housing.

5. The lens driving device according to claim 4, wherein the lens driving housing encloses the lens carrier, wherein the third opening directly faces the lens driving housing in a manner that the lens barrel directly faces against the lens driving housing through the third opening.

6. The lens driving device according to claim 5 further having a cover closing a front side thereof, wherein the cover directly faces the third opening.

7. The lens driving device according to claim 1, wherein the lens carrier is driven along an optical axis direction of the lens barrel.

8. A camera device comprising

a lens barrel;

a lens driving device; and

a photo detecting sensor that receives light passed through the lens barrel, wherein the lens driving device includes:

a box-shaped lens carrier for fixing a lens barrel to the inside thereof which lens barrel is for guiding light from an imaging target to a photo detecting sensor, wherein

the lens carrier has two parallelly opposing side walls each of which has an upper end, a lower end, a front end, and a rear end, wherein

a first opening through which light from the imaging target enters is formed between the upper ends of the two parallelly opposing, side walls, a second opening through which light toward the photo detecting sensor exits is formed between the lower ends of the two parallelly opposing side walls, a third opening for mounting the lens barrel

is formed between the front ends of two parallelly opposing side walls, and a fourth opening is formed between the rear ends of two parallelly opposing side walls, wherein

inner surfaces of the two parallelly, opposing side walls are formed in parallel with respect to each other from the front ends to the center of the lens carrier.

9. An electronic apparatus being equipped with a camera device including:

a lens barrel;

a lens driving device; and

a photo detecting sensor that receives light passed through the lens barrel, wherein

the lens driving device includes:

a box-shaped lens carrier for fixing a lens barrel to the inside thereof which lens barrel is for guiding light from an imaging target to a photo detecting sensor, wherein

the lens carrier has two parallelly opposing side walls each of which has an upper end, a lower end, a front end, and a rear end, wherein

a first opening through which light from the imaging target enters is formed between the upper ends of the two parallelly opposing side walls, a second opening through which light toward the photo detecting sensor exits is formed between the lower ends of the two parallelly opposing side walls, a third opening for mounting the lens barrel

is formed between the front ends of two parallelly opposing side walls, and a fourth opening is formed between the rear ends of two parallelly opposing side walls, wherein

inner surfaces of the two parallelly opposing side walls are formed in parallel with respect to each other from the front ends to the center of the lens carrier.

10. The lens driving device according to claim 4, wherein the lens carrier is driven together with the lens barrel therein along an optical axis direction of the lens barrel inside the lens driving device housing.

11. The lens driving device according to claim 5, wherein the fourth opening directly faces the lens driving device housing in a manner that the lens barrel directly faces against the lens driving device housing through the fourth opening.

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